

# Status of NASA Earth observation sensors, data and methods for SERVIR: a focus on disaster management in Nepal

Eric Anderson, March 2016

NASA/SERVIR Science Coordination Office



- SERVIR is a link between research institutions and end user decision making.
- SERVIR efforts are led by the needs of the region. Some examples include hydrologic modeling, crop yield estimation, land cover change detection, and hydro-meteorological hazard monitoring
- Presence of SERVIR Hubs, such as ICIMOD, RCMRD, and ADPC, with regional governmental support, makes the linkage sustainable.



## Satellite missions and value-added products

- Landsat series
- ASTER and EO-1
- VIIRS Day-night Band
- *Under Study:* SWOT (Surface Water and Ocean Topography) mission
- *Under Study:* NISAR (NASA-ISRO Synthetic Aperture Radar) mission
- SRTM-2 DEM for various applications

## Data services and processing systems

- ClimateSERV data processing system for water resources management
- GPM and SMAP missions for rainfall and hydrology applications

## Hazard and disaster event monitoring and response support

- NASA and ICIMOD disaster response support for the Nepal earthquake
- Glacial lake and landslide hazards

# Satellite missions and value-added products

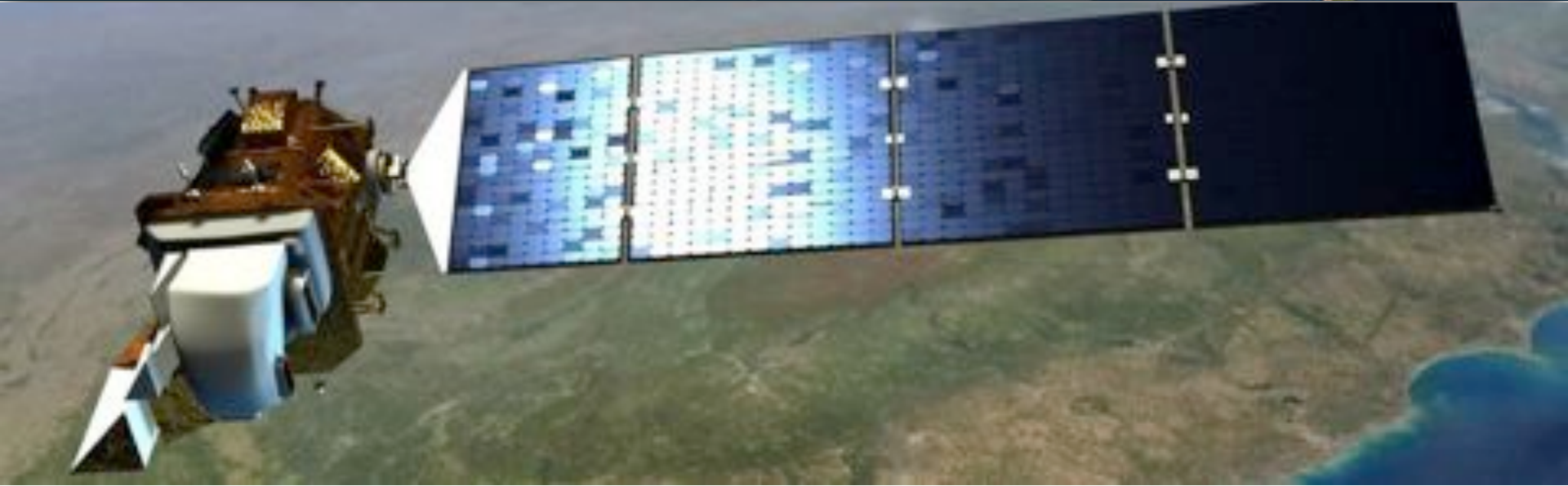


- Continuous 40+ year record of terrestrial ecosystem variables
- Further science and applications with Sentinel-2 (ESA)
- Landsat 8 higher level products available upon request from <http://earthexplorer.usgs.gov>
  - Surface reflectance (atmospheric correction)
  - Land surface temperature
  - [http://landsat.usgs.gov/CDR\\_LSR.php](http://landsat.usgs.gov/CDR_LSR.php)





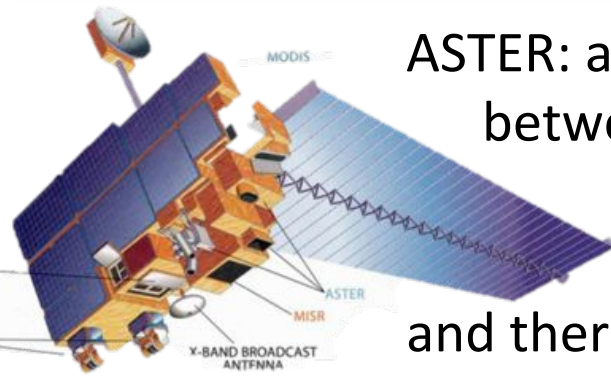
# The Landsat Mission continues...



Planned to launch in 2023, Landsat 9 will continue the longest space-based record of Earth's land—past the half century mark.

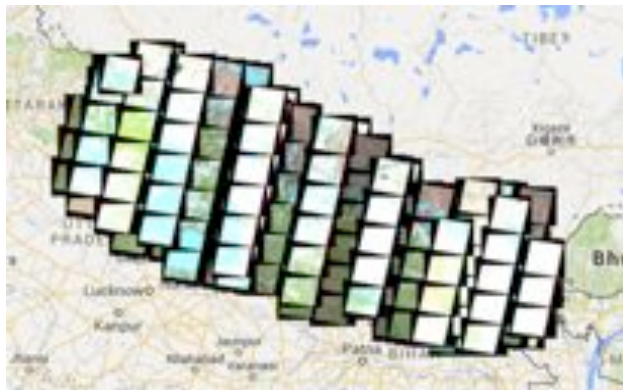
- <https://www.nasa.gov/press/2015/april/nasa-usgs-begin-work-on-landsat-9-to-continue-land-imaging-legacy>
- <http://landsat.gsfc.nasa.gov/?p=10391>

# ASTER sensor and EO-1 satellite



ASTER: a collaboration between NASA and JAXA; visible-near infrared and thermal, on board Terra satellite

- 2000 to present



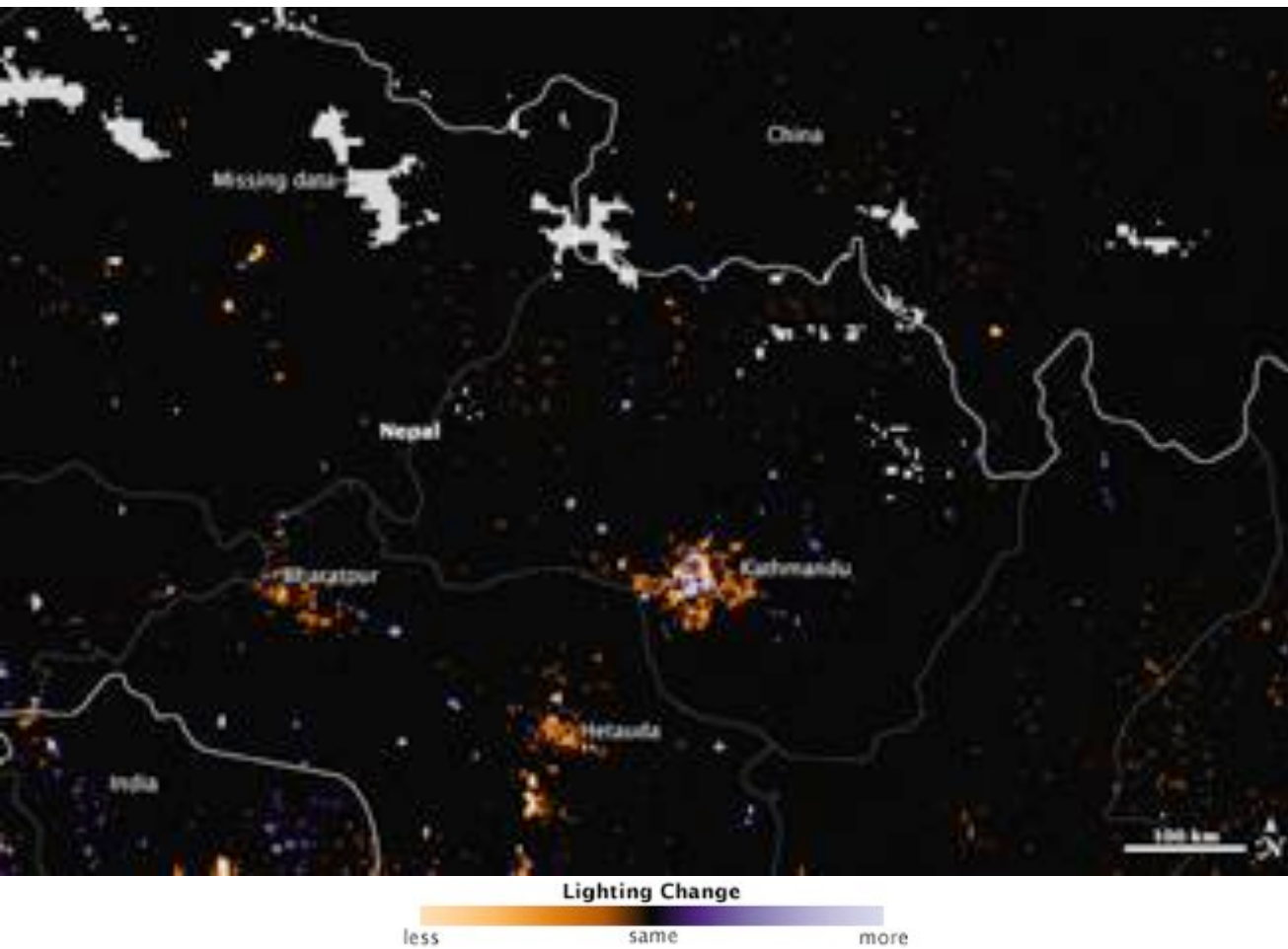
EO-1 (Earth Observing-1): a validation mission for Landsat continuity (ALI) and hyperspectral land imaging (Hyperion)

- 2001 to present



**Both have offered targeted and expedited imaging for specific SERVIR areas of interest**

# VIIRS Day-Night Band on Suomi NPP Satellite



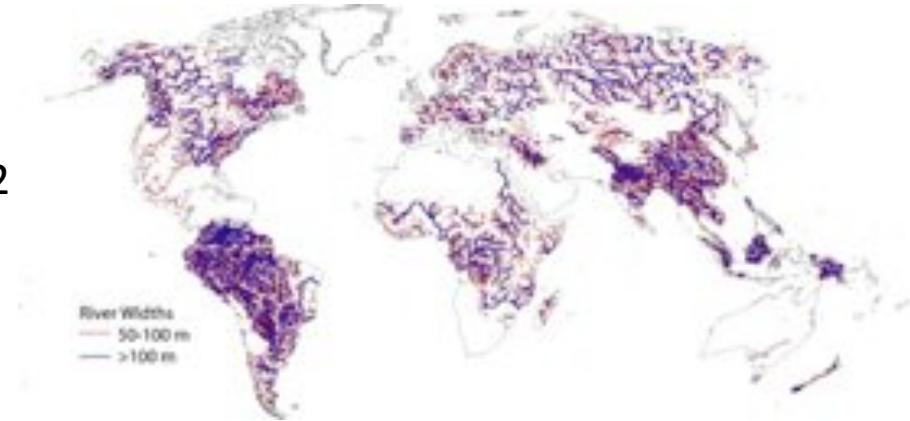
Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on the Suomi NPP satellite, shows how the amount of light emitted by towns and cities in Nepal changed before and after the earthquake. (NASA/SPoRT)



# Under Study: SWOT - Surface Water and Ocean Topography mission



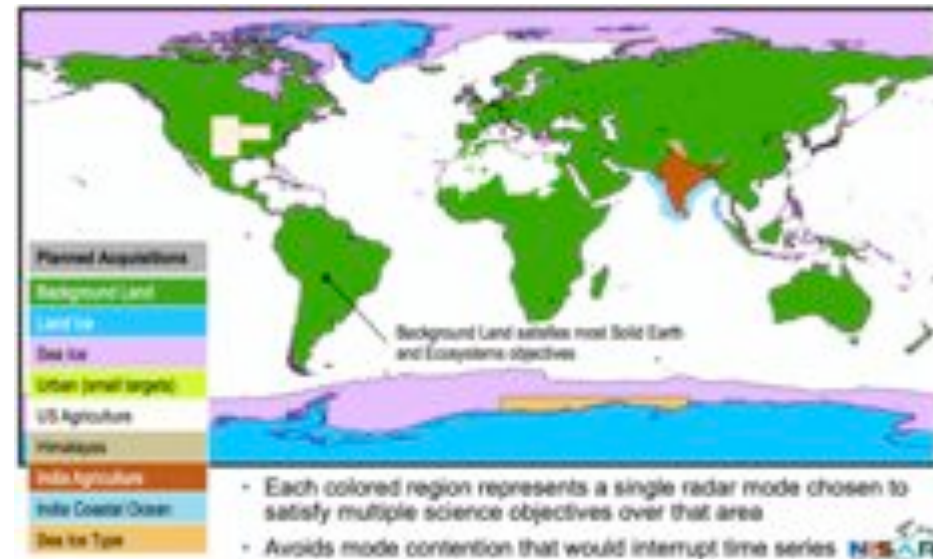
- New key objectives for hydrology
  - Global inventory and change patterns of surface water bodies  $>250\text{m}^2$  and rivers  $>10\text{km}$  long and  $>100\text{m}$  wide
  - 21 day repeat coverage; accuracy within 10cm
- Science application to improve river discharge estimates
- 2020 launch planned



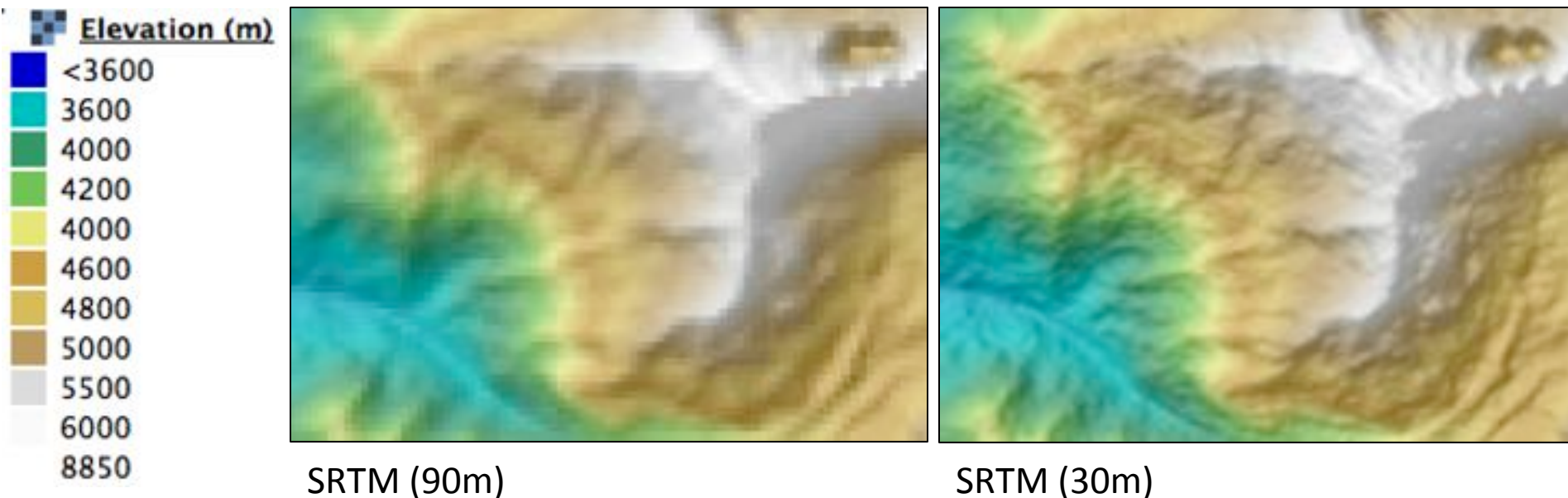
Pavelsky et al., 2014  
<http://dx.doi.org/10.1016/j.jhydrol.2014.08.044>

# Under Study: NISAR (NASA-ISRO Synthetic Aperture Radar) mission

- A dedicated U.S. and Indian InSAR mission, in partnership with ISRO, optimized for studying hazards and global environmental change.
  - ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides
- L-band and S-band also provide data for ecosystem and agricultural monitoring
- 2020 launch planned



- Global 1 arc second (30m) elevation data
  - Freely available through <http://reverb.echo.nasa.gov/> and <https://lpdaac.usgs.gov/>



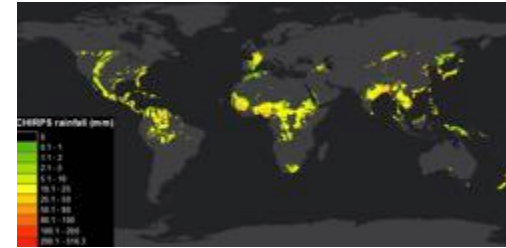
# Data services and processing systems





<http://ClimateSERV.nsstc.nasa.gov/>

Many users do not need global data for each day, instead need only information for their geographic area of interest and for their time period of interest.

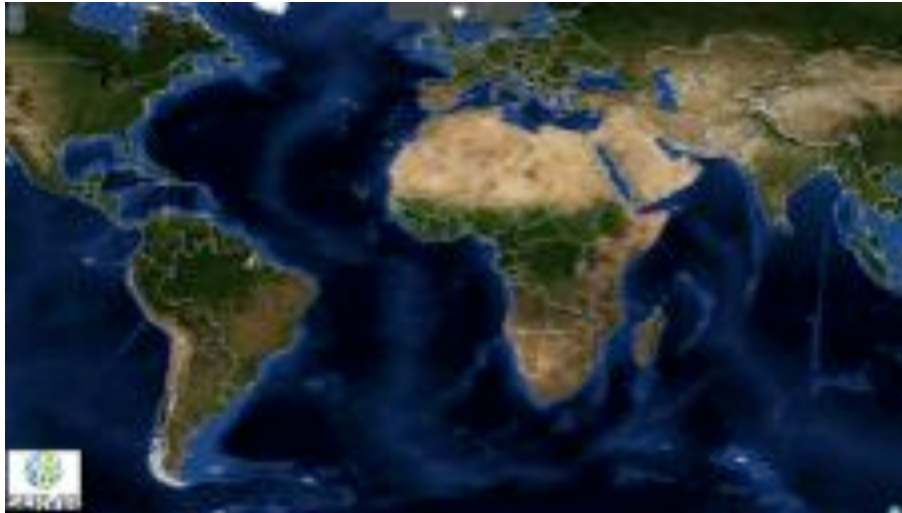


SERVIR has built the ClimateSERV data processing system to analyze and deliver global or regional data for the time period and area of interest.

- *Built on the following free and open datasets:*
  - CHIRPS global rainfall data (FEWS NET)
    - 0.05° spatial resolution (~5 km)
    - Consistent, daily rainfall records since 1981
  - NMME Seasonal climate forecasts (NASA/SERVIR)
    - 0.5° spatial resolution (~50 km).
    - Daily rainfall and temperature for 180 days in advance, updated monthly
  - eMODIS vegetation index (NDVI, for West Africa, USGS)
    - 250 m spatial resolution. Pentadal, available since 2001

# ClimateSERV Data Processing

SERVIR



Create Area of Interest  
Or choose predefined geometry



Select parameters, data  
type and date ranges

New Search

Select Date Type: CHIRPS Precip

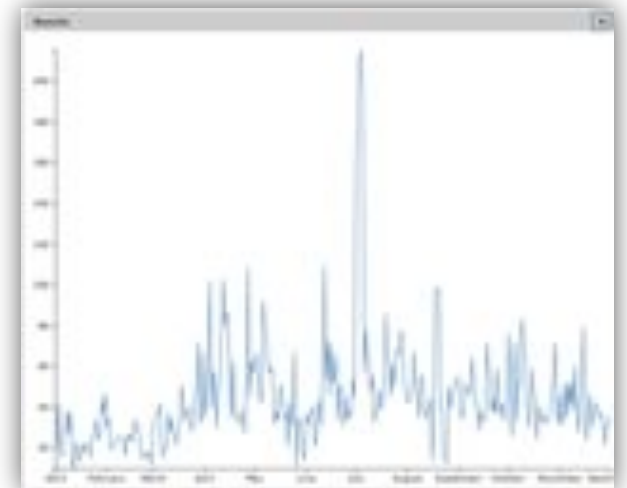
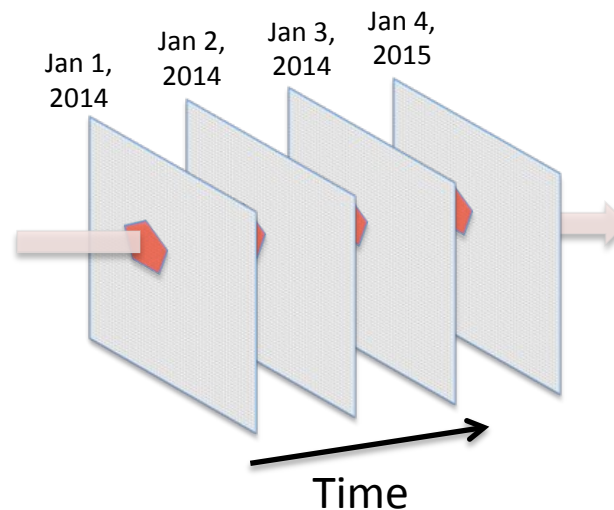
Select operation Type: Average

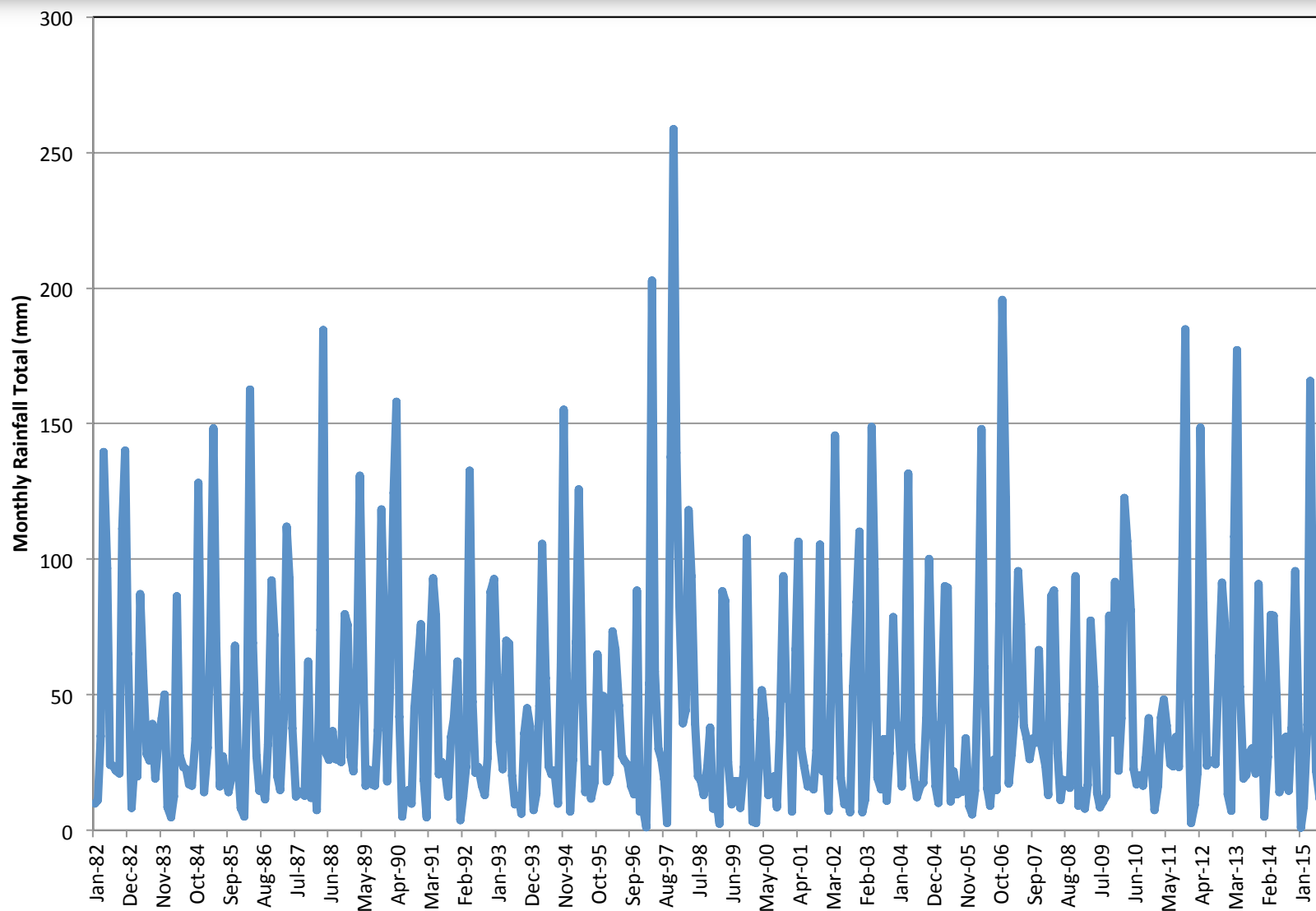
Date Interval: Daily

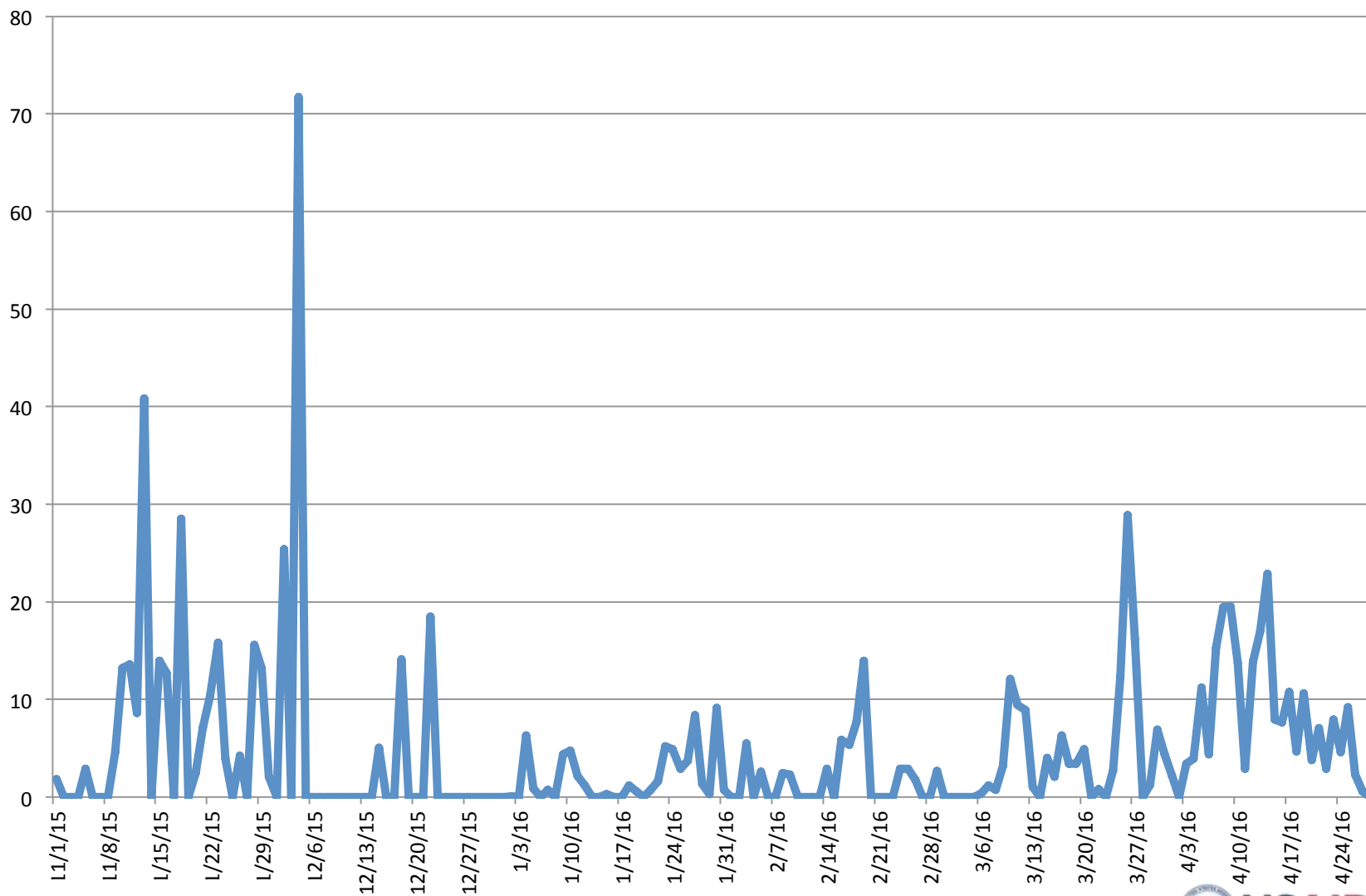
Begin Date: 01/01/1982

End Date: 01/31/2015

Submit Cancel



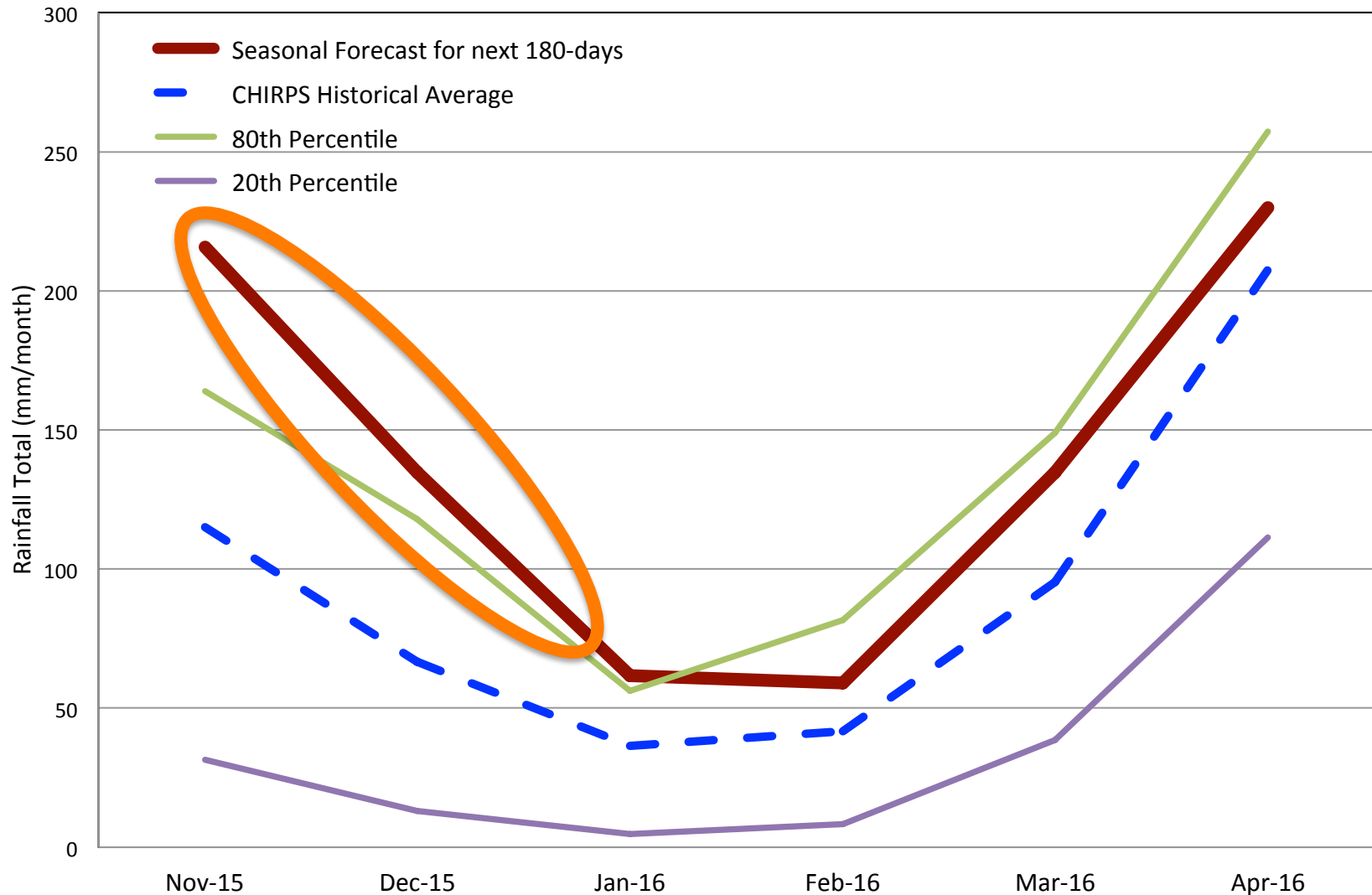






# Monthly Rainfall for Kenya for next 180 days

## Combining CHIRPS and Seasonal Rainfall Forecasts



# Next Steps and Request for Feedback on ClimateSERV



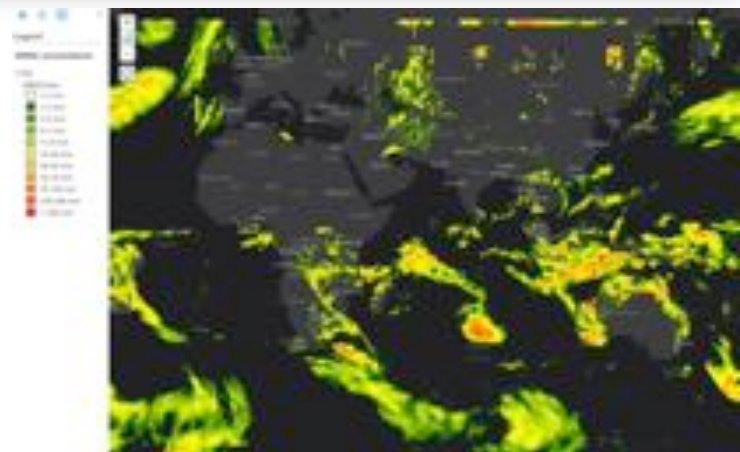
- We are adding more functionality to this portal.
  - Multiple ensembles on the same plot, download
  - Cumulative rainfall
  - Combined historical perspective on the forecast plots
- We request you to use this system to see whether it provides the desired capabilities.
  - Request you to send what you would like to see added
- Two types of feedback requested via email
  - Functionality on existing features (statistics, data processing, plotting, raw data access)
  - Additional features, and datasets

# GPM – Global Precipitation Measurement Mission

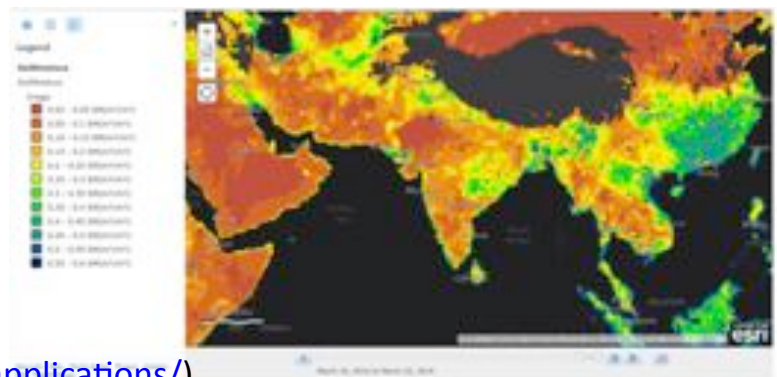
## SMAP – Soil Moisture Active-Passive Mission



- **GPM IMERG Web Map Service**
  - <https://servirglobal.net/Global/Articles/Article/1452/servir-new-web-service-streamlines-use-of-key-precipitation-data>
- 0.1°, 30-min precipitation products
- Hydrology applications
  - Floods (<http://pmm.nasa.gov/applications/floods>)
  - Landslides (<http://pmm.nasa.gov/applications/landslides>)



Follow on TRMM-based flood and landslide monitoring  
<http://pmm.nasa.gov/TRMM/flood-and-landslide-monitoring>



- **SMAP applications** (<http://smap.jpl.nasa.gov/science/applications/>)
  - monitoring soil moisture to improving understanding of water cycle, weather and climate forecasting, droughts, fires, floods, landslides, and agricultural productivity
  - Web map service:  
<http://gis1.servirglobal.net/arcgis/rest/services/Global/SoilMoisture/MapServer>

# **Hazard and disaster event monitoring and response support**





# NASA and interagency response support to 2015 earthquake

## Gorkha (Nepal) Earthquake Response

### NASA Activities

NASA and its partners are developing products using optical and radar satellites to support analysis and assessment efforts for the April 25, 2015, magnitude 7.8 earthquake in Nepal, referred to as the Gorkha earthquake. The products consist of maps and analyses used to determine the type and extent of earthquake-related damage, and are grouped into six thematic categories below.

For additional information, descriptive news, and images please go to the [Gorkha Earthquake Image Gallery](#) page on the NASA portal.

#### Overview



**Damage and Vulnerability Maps**  
Assessment of impact using imagery and exposure analysis to determine the extent of damage and affected buildings and population.



**Damage Proxy Maps**  
Maps of Damage generated by algorithms to rapidly detect surface changes caused by natural or human-produced damage.



**Surface Deformation Measurements**  
Measurements of deformation of the Earth's surface made from analysis of satellite data. This includes deformation analysis of synthetic aperture radar (SAR), optical imagery, and Global Navigation Satellite System (or Global Positioning System, GPS).



**Surface Deformation Modeling**  
Modeling of the deformation of the Earth's surface.



**Induced Hazards: Landslides and Floods**  
Induced hazards subgroup focuses on landslides, flooding and other geohazards relating to the Gorkha earthquake and its aftermath. The group is involved with imagery analysis and product development to provide information to researchers and operational groups within the affected



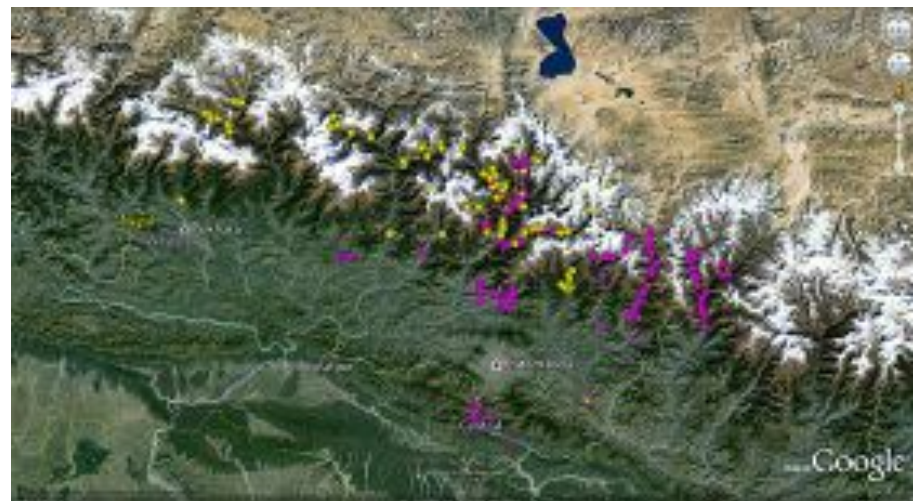
**Optical Imagery Products**  
Remotely sensed imagery of the Earth.

<http://weather.msfc.nasa.gov/sport/disasters/gorkha/>

# Support for disaster response efforts after Nepal earthquake



- 23,000+ “tiled” NASA and commercial satellite images to ICIMOD in Nepal
- Satellite tasking recommendations



4000+ landslides identified by the NASA-USGS-ICIMOD Interagency Volunteer Earthquake Response Team (incl. SERVIR Applied Science Team PIs Kargel and Kirschbaum) (Kargel et al. 2016)

[http://www.nasa.gov/mission\\_pages/servir/software-developed-by-servir-interns-aids-nepal-earthquake-response.html](http://www.nasa.gov/mission_pages/servir/software-developed-by-servir-interns-aids-nepal-earthquake-response.html)  
Images from <http://www.icimod.org/?q=17851> and <https://www.facebook.com/icimod>



GIS/remote sensing experts at ICIMOD and volunteers preparing maps for earthquake disaster response



Nepal's Deputy Prime Minister, Minister of Home Affairs, other senior gov. officials visit ICIMOD



# Glacier and Alpine Hazards in Relation to Development and Habitation in the Hindu Kush-Himalaya

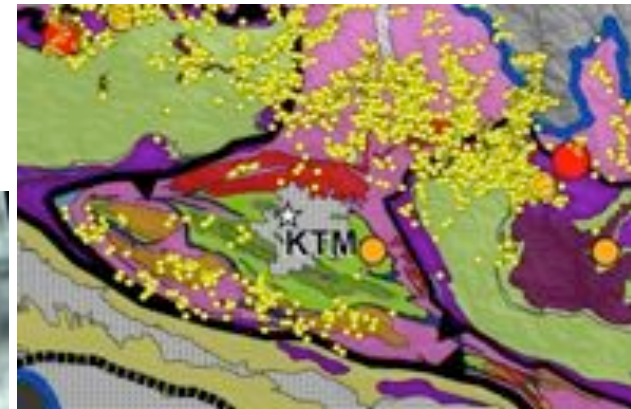
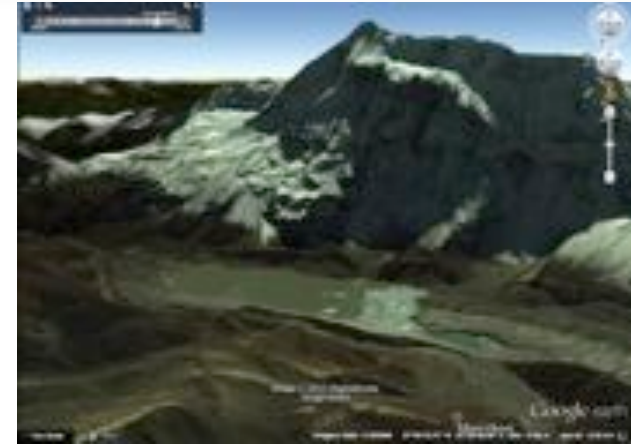
Jeffrey S. Kargel, Gregory Leonard, Umesh Hairitashya, Dhananjay Regmi, Michael Bishop, and Dan Shugar, other "Landslide Volunteers"



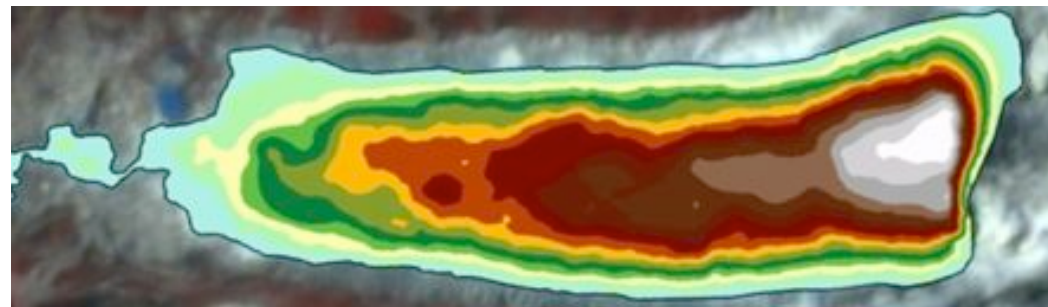
## A "SERVIR Applied Sciences Team" Project.

### Main activities:

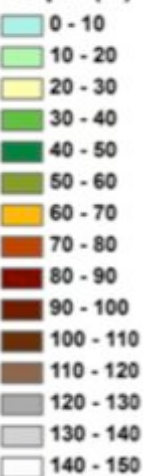
- Satellite and field assessment of mountains hazards and disasters and their process chains (lakes, glaciers, outburst floods, earthquake-induced landslides)
- Field and remote sensing investigation of Lower Barun Lake (one of Nepal's most dangerous).
- Assessments/datasets: Seti River disaster, earthquake-induced landslides, and glacier lakes bathymetry and hazards



Kargel et al., 2016. *Science*.



Imja Lake  
Depth (m)



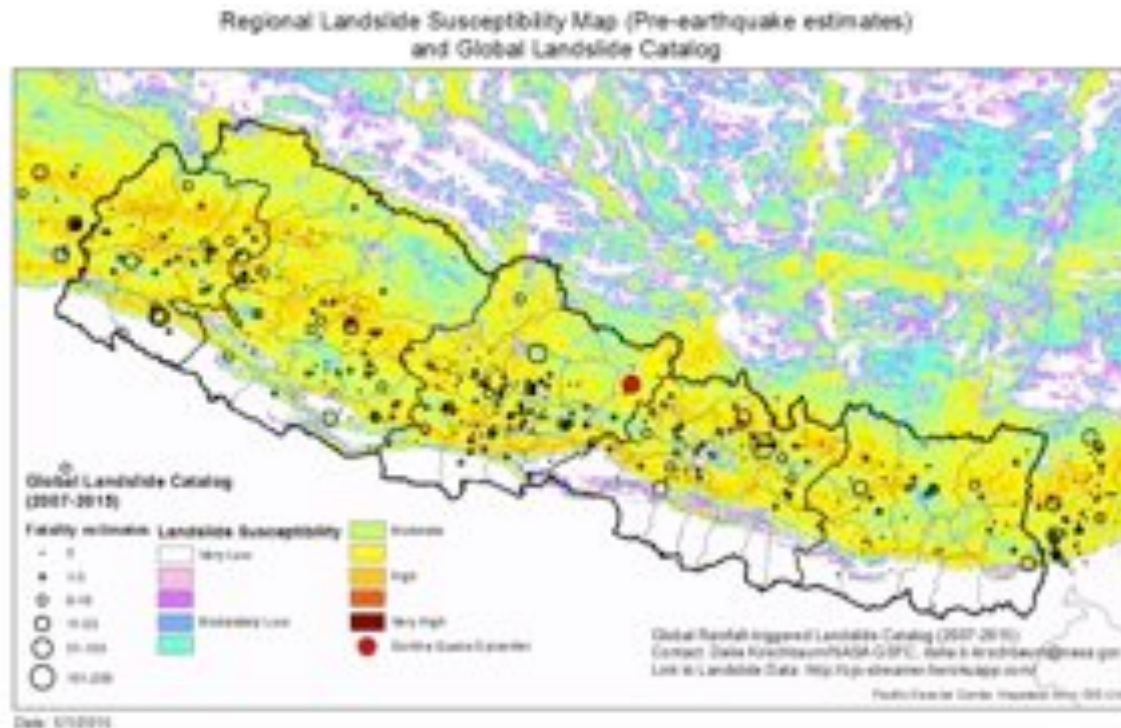
# Landslide Hazard Assessment and Forecasting System using near real-time remote sensing information over HKH region

Dalia Kirschbaum, NASA Goddard Space Flight Center; Jose Cepeda, Norwegian Geotechnical Institute; Stuart Frye, SGT/GSFC; Sujay Kumar, SAIC/GSFC, Joe Santanello, NASA GSFC



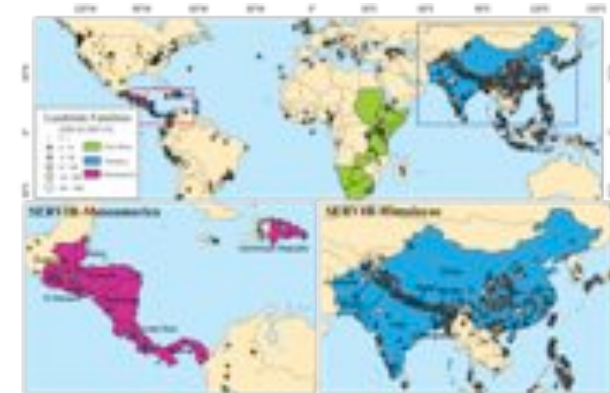
## A “SERVIR Applied Sciences Team” Project. Objectives:

- Landslide susceptibility and exposure mapping
- Calculation of rainfall thresholds
- Automation of daily landslide hazard in online platform
- Feasibility test and prototype system for Nepal



Now open source: <https://github.com/vightel/ojo-processing/tree/master/python>

<http://ojo-streamer.herokuapp.com/nepal>



Global Landslide Catalog

## Relevant Publications:

Kirschbaum, D.B., Stanley, T., Zhou, Y., 2015. Spatial and Temporal Analysis of a Global Landslide Catalog. *Geomorphology*. doi:10.1016/j.geomorph.2015.03.016

Kirschbaum, D.B., Stanley, T., Yatheendradas, S., 2015. Modeling Landslide Susceptibility over Large Regions with Fuzzy Overlay. *Landslides*. doi:10.1007/s10346-015-0577-2

Kirschbaum, D.B., Stanley, T., Simmons, J., *in review*, 2015. A Dynamic Landslide Hazard Assessment System for Central America and Hispaniola. *Nat. Hazards Earth Syst. Sci.* 1–32.

Kirschbaum, D.B. Cappelaere, P., Frye, S., Mandl, D., Stanley, T., *in preparation*, 2015. Multi-scale, Multi-architecture for Disasters and Science. *Computers & Geoscience*.



# Thank you


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# SERVIR Product Catalog



 GLOBAL

PRODUCT CATALOG

Welcome to the SERVIR Global Product Catalog. Observations and NASA Products to inform resilience.

NARROW BY:

Region






Theme

Status

Date Source

Type

PRODUCT CATALOG




## CLIMATESERV

This tool allows development practitioners, scientists/researchers, and government decision-maker to visualize and download historical rainfall data, vegetation condition data, and 180-day forecasts of rainfall

In SERVIR regions, where long-term ground observations of rainfall are sparse, there is a critical need for satellite and model-derived rainfall data for predicting droughts, estimating crop yields, and more. Decision makers need a way to accurately assess how severe a drought will be, how it compares to past droughts, and its potential effect on crop yields. Such assessments require accurate estimations of rainfall variations in space and time. It is important to place an evolving dryer-than-normal season into historical context in order to analyze the severity of rainfall deficits. Until now, such analyses used rainfall data from specific points on the Earth's surface. However, that data fails to show the region-wide variability that reveals comprehensive rainfall patterns.

[See Definition Document](#)



Theme: Adaptation, Climate  
Region: Himalaya

ClimateSERV

Theme: Agriculture, Climate, Weather, Water  
Region: Global

Status: Active

CREST Streamflow Viewer – Eastern Africa and Bhutan

Theme: Adaptation, Agriculture, Climate, Disaster, Water, Weather  
Region: Eastern/Southern Africa, Himalaya

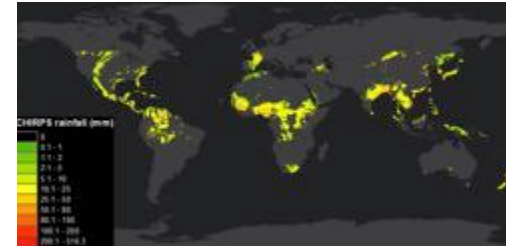
Status: Active

<http://servircatalog.net> / <http://servircatalogue.net>

# Backup slide: ClimateSERV input data details

SERVIR

<http://ClimateSERV.nsstc.nasa.gov/>



- CHIRPS global rainfall data (FEWS NET)
  - 0.05° spatial resolution (~5 km)
  - Consistent, daily rainfall records since 1981
  - Funk et al., 2015 doi:10.1038/sdata.2015.66 2015 and several others
- NMME Seasonal climate forecasts (NASA/SERVIR)
  - 0.5° spatial resolution (~50 km).
  - Daily rainfall and temperature records for 180 days in advance.
  - Updated every month, around the 10<sup>th</sup> of the month
  - Robertson et al., 2015 <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150000716.pdf>
  - Sikder et al., 2016 <http://dx.doi.org/10.1175/JHM-D-14-0099.1>
- eMODIS vegetation index (NDVI, for West Africa, USGS)
  - 250 m spatial resolution. Pentadal, available since 2001

# Backup slide:

## ClimateSERV input data availability



The CHIRPS, eMODIS, and NMME data are available from a variety of sources

- Famine Early Warning System (FEWS NET)
  - CHIRPS: <ftp://chg-ftpout.geog.ucsb.edu/pub/org/chg/products/CHIRPS-2.0/>
  - eMODIS: <http://earlywarning.usgs.gov/fews>
- NOAA National Centers for Environmental Prediction (NCEP)
  - <http://www.cpc.ncep.noaa.gov/products/NMME/>
  - <http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/>

